

DELAWARE VALLEY FORMS OF TRACHELOMONAS.

BY T. CHALKLEY PALMER.

The uniflagellate protozoa belonging to the genus *Trachelomonas* are normally provided with intensely green chromatophores, a red pigment-spot, a contractile vacuole and a hard, brittle, brownish lorica. The lorica has a single aperture wherethrough issues the very long flagellum. With the aid of this flagellum the monad swims rapidly in an irregularly spiral course. Though habitually inhabiting the lorica, the monad is able to squeeze through the very small aperture and to swim naked; and almost any rich gathering of *Trachelomonas* will show numerous individuals in this condition, wherein they are scarcely to be distinguished, except by minute study, from species of the normally naked genus *Euglena*. Different species of *Trachelomonas*, when without their loricae, are not at all recognizable. Specific distinctions, in short, are founded of necessity, in this genus, on lorica characters.

These loricae, when heated nearly to redness on a cover-glass, still keep their shapes, and show only a certain loss of transparency and a considerable reddening of the originally brown color. The ability to withstand a high degree of heat was taken by early students of the genus as an indication of their silicious constitution. When, however, these loricae are treated with acids, the hardness, brittleness and color gradually disappear, and soon nothing remains but a thin, gelatinous pellicle, which in turn is capable of gradual and complete solution in hot nitric acid or in sulphuric acid and bichromate of potash. The mineral matter they contain is, therefore, something other than silica; and Klebs,¹ among others, has stated that this mineral matter is, in some cases at least, ferric hydroxide. The test to determine this point is sufficiently simple. It is only necessary to burn the loricae on a cover-glass, and to invert over a drop of a solution of potassium ferrocyanide containing a small addition of hydrochloric acid. In a very few minutes the acid begins to dissolve the oxide of iron, and simultaneously ferric ferrocyanide deposits as a blue cloud around each of the loricae. The writer has put to this test most of the loricae pertaining

¹ KLEBS, *Untersuch. Tubing. Inst.*, I, 1883.

to the Delaware Valley species, and in every case the result was as described.² During this investigation numerous loricae were also dried upon the cover-glass without burning, and examined for carbon dioxide with hydrochloric acid. The result was negative in every case. The lorica of *T. piscatoris* was included in these tests. The supposition of Fisher,³ that these loricae are to a considerable extent composed of calcium carbonate, is therefore still without confirmation. The effervescence observed by Fisher, and attributed by him to carbon dioxide, may be capable of another explanation.

Reduplication in the genus *Trachelomonas* is usually, if not always, accomplished within the lorica, and the act is followed normally by the withdrawal of one of the newly formed monads through the minute aperture. This operation has been observed frequently by students, so that its apparent impossibility goes for nothing. The naked individuals already referred to are largely the product of this process. Subsequently, but after how great an interval of time is uncertain, the euglenoid form is lost, the body assumes the spherical or ovoid shape proper to the species, and a new shell is secreted. This process the writer has seen in part. The individual was of the species *T. hispida*. The shell was already outlined as a very tenuous layer of nearly invisible gelatin, to the outside of which clung a dim halo of inert minutæ. But this soft and adherent condition was only transitory. The animal, revolving tirelessly within the nascent, stationary shell, continued without ceasing to brush and pat and feel all over the surface with its wonderful flagellum. By degrees the débris was mostly dislodged. Within two hours the lorica was beginning to take on a slight tint; it had attained to a consistency, though the spines characteristic of the mature shell were still almost invisible. Very suddenly the lorica itself began to revolve with the revolving monad, and in a moment monad and lorica were gone.

It sometimes happens that after subdivision the withdrawal of one of the monads does not at once follow. Loricae are to be seen, now and again, with two monads, much pressed for room, and with flagellæ mutually interfering and working at cross-purposes. The course of the

² These loricae are, therefore, altogether different from the silicious shells described by the present writer in these PROCEEDINGS, 1902, and there placed tentatively in the genus *Trachelomonas*. Some of those described and figured, and a few among the large number of similar ones observed, were afterwards seen in living but quiescent condition, and the indications are that they represent the resting or encysted state of various Protozoa, some of which at least belong to the Chromomonadina. It was, therefore, a complete error to refer them to the genus *Trachelomonas*.

³ FISHER, 1880, *Proc. Amer. Soc. Micros.*

combination through the water is then erratic beyond what is usual. Loricæ occur, also, with duplicate apertures, though whether such are due to a similar state of affairs, only more prolonged, may be matter of doubt. Sporulation, or the splitting up of the whole monad into a multitude of very small, monoflagellate spores, which has been observed in this as well as in other genera of the Protozoa, is evidently a less frequent phenomenon. The evidence of it, however, is often seen in the numerous very small loricæ of many shapes. These small loricæ cannot with any certainty be referred to species, since in them the specific features are to a large extent undeveloped. The different steps of the process that results at last in a fully developed monad, starting from these spores, would seem not to have been followed by students. It is evident, however, that the steps are few; since while very small loricæ are common, medium-sized ones are comparatively rare. Authors have endeavored, and generally with success, to confine their descriptions in this genus to mature forms. The specific characters being almost without exception founded on the shape, size and surface markings of the loricæ, it is at once evident that for specific diagnosis these loricæ should be fully formed. It would seem, however, that in a few cases this principle has not been in operation to the fullest extent possible, and a few species are in consequence not quite adequately characterized. In the descriptive part that follows, only the loricæ that are mature, as manifested by their full development in point of color, size and markings, are accepted as typical.

All the species of *Trachelomonas* known to the writer are found in fresh water. Roadside pools, ditches, ponds, all yield them in larger or smaller numbers. They congregate in particular around rusty patches where ferrous compounds oozing out of the soil are in process of oxidation and precipitation. They often abound, however, in still waters covered with *Lemna*, and in those filled with *Utricularia*, *Potamogeton* and other aquatics.

Klebs has described⁴ two forms of *Trachelomonas* that are devoid of chlorophyll, one of which he has named *T. reticulata* and the other *T. volvocina* var. *hyalina*. Both occur in decaying organic solutions, and are no doubt of saprophytic habit. Neither of these appears to have been noted in the territory covered by this paper.

In the table of species all the well-known forms are given whether known in Delaware Valley or not. A single form, not considered of specific value, is distinguished by an asterisk.

⁴ KLEBS, *Untersuch. Tubing. Inst.*, I, 1883.

ANALYSIS OF SPECIES.

I.—*Lorica nearly spherical.*

Surface marked with	{	Surface smooth or nearly so, ...	<i>T. volvocina.</i>
		Hemispherical elevations, ...	<i>T. verrucosa.</i>
		Obliquely transverse, irregular, crooked wrinkles, . . .	<i>T. rugulosa.</i>
		Longitudinal, somewhat oblique, continuous ridges, . .	<i>T. Stokesiana.</i>

II.—*Lorica not spherical.*

Surface nearly smooth.	{	Not caudate, aperture produced, outline somewhat quadrate.	{	Narrowly cylindrical, <i>T. cylindrica.</i>		
				Broader, flask-shaped, <i>T. euchlora.</i>		
		Caudate, aperture produced, outline not quadrate.	{	Vasiform, aperture denticulate, <i>T. urceolata.</i>		
				Pyriform, aperture smooth, oblique, <i>T. acuminata.</i>		
General surface not smooth.	{	Not caudate, outline ovate, aperture rim wide, crenulate, <i>T. eurystoma.</i>				
		Spirally ridged. Aperture in an oblique groove, ... <i>T. torta.</i>				
		Punctate {	{	Punctæ fine, uniform. { A posterior crown of large spines, <i>T. armata.</i>		
				Two rows of spines around aperture. { No posterior spines, * <i>T. acanthostoma.</i>		
		Reticulate.	{	Punctæ coarse, irregular, ... <i>T. crebea.</i>		
				Lorica ovoid. Cell-contents colorless, . . <i>T. reticulata.</i>		
		Spines short, stout, thickly set.	{	Ovoid, ends equally rounded, <i>T. hispida.</i>		
				Tapering posteriorly, caudate, <i>T. caudata.</i>		
		Spiny.	{	Spines short, more slender, less thickly set.	{	Rounded in front, obtusely conical poste- riorly, ... <i>T. obtusa.</i>
						Both ends rounded.
				Spines long and large, numerous. Neck trumpet-form, wavy, ... <i>T. horrida.</i>	{	

Trachelomonas volvocina Ehr.

Trachelomonas volvocina Ehrenberg. 1833. Abh. Berlin. Akad.

Lorica spheroidal, brown, surface nearly smooth. Aperture plane or produced into a cylindrical tube, which may be normal to the surface or slightly oblique.

This is perhaps the most common of local species, and very variable. The lorica may be prolately—or oblately—spheroidal, and of any size from very minute to 29 μ in diameter. The oblately spheroidal forms seldom exhibit any tube-like prolongation, but often a wide saucer-shaped depression surrounds the aperture and the wall is at that point very heavy. The tube, when present, may be altogether without the lorica, or partly within it and attached to the apex of a funnel-shaped depression in the wall. The surface of the finished lorica is almost smooth, or at most slightly wavy, though the intimate granular nature of the wall may at times be made out.

Trachelomonas verrucosa Stokes. Pl. XLI, fig. 2.

Trachelomonas verrucosa Stokes. 1887. Proc. Amer. Philos. Soc., XXIV.

"Lorica subspherical, colorless, the entire surface covered with minute hemispherical elevations, the anterior extremity slightly emarginate."

This species is not uncommon in the Delaware Valley, and it is especially plentiful at times in tidal ditches. As observed, it agrees closely with the description as quoted from Dr. Stokes, except only that the lorica is very generally brown instead of colorless. The hemispherical elevations sometimes show a slight tendency to elongate. Observed maximum diameter 24 μ .

Trachelomonas rugulosa Stein. Pl. XLI, figs. 7 and 8.

Trachelomonas rugulosa Stein. 1878. Infusionsthiere, III.

Lorica subspherical, thick-walled, brown. Surface with short, irregular, transverse to oblique, crooked wrinkles. Aperture plane, generally surrounded by a flat, smooth area.

Observed maximum diameter 23 μ .

It is a present tendency to reduce this form to a variety of *T. volvocina*. Immature individuals of the spheroidal species show resemblances that are more or less puzzling. No doubt these species are closely related and of recent differentiation. But the well-developed, highly colored, mature loricae seem to differ with a sufficient constancy.

Published figures of the present species, mostly copied from Stein, are naturally quite as nebulous and unsatisfactory as Stein's own. Since it is proposed to insist herein upon the apparent validity of this species, the mature lorica, as it occurs along the Delaware, is illustrated in Pl. XLI, figs. 7 and 8, with such fidelity as was attainable. The markings vary in development from faint, elongated dots to crooked, confluent ridges. These ridges are by no means uniformly arranged spirally in the manner indicated in Stein's figures; and the internal spiral vestiges, shown in one of these figures, can scarcely constitute a specific character, since the like may often be seen, under favorable conditions, in almost any species of the genus.

The form figured was collected in numbers in Tinicum, August, 1903. Others quite similar were observed at Penn Valley, September, 1904. The same species, collected at Hammonton, New Jersey, in 1902, showed confluent rugosities that could only be described as cerebroid convolutions. In none of these was observable any tendency toward production of the aperture into a tube like that of *T. volvocina*. In every way *T. rugulosa* seems much more closely related to *T. verrucosa* than to *T. volvocina*. Certain plainly immature conditions resemble

figures of *T. rugulosa* hitherto published, but no valid conclusions as to specific relationships are to be drawn from such.

Trachelomonas Stokesiana sp. nov. Pl. XLI, figs. 4 and 5.

Lorica spheroidal, thin-walled, one-tenth longer than broad, at maturity dark brown. Surface with conspicuous, mostly distinct, occasionally anastomosing, continuous ridges, obliquely longitudinal on the sides, strongly spiral at the ends. Aperture a round, bluntly conical, short tube, seated in a shallow circular depression. Monad green, with red pigment-spot. Flagellum long.

Observed maximum length of lorica 18 μ . Ponds, Penn Valley, Bucks county, Pennsylvania.

This species differs from *T. rugulosa* in the thinner wall of the mature lorica, in its smaller size, in its shape, and in the character and disposition of the markings. It differs from *T. torta* in size, shape, aperture and markings.

It was collected in large numbers at Penn Valley during the summer and autumn of 1904. With it were smaller numbers of *T. armata*, *volvocina* and *hispida*. Later it was found, but sparsely, in Tinicum, where, however, the remarkable constancy of its characters was again in evidence. The monad moves rapidly in an irregular spiral. Many individuals were observed in the naked condition, and the pigment-spot was then seen without difficulty.

I am glad of the permission to name this species in honor of Dr. A. C. Stokes, of Trenton, New Jersey, whose work in this and other genera of the Protozoa is known to all students.

Trachelomonas cylindrica Ehr.

Trachelomonas cylindrica Ehrenberg. 1833. Abh. Berlin. Akad.

Lorica reddish-brown, narrowly cylindrical, ends slightly flattened, smooth. Aperture plane or produced into a short, straight or oblique tube with smooth limb. Length 25 μ .

Only a few specimens of this have been seen by the writer, all of them coming from Tinicum. They accompanied the following species, which they resembled in a general way, really differing therefrom in loricate characters only in being very much narrower, and mostly of a deeper color.

Trachelomonas euchlora (Ehr.) comb. nov.

Lagenella euchlora Ehrenberg. 1833. Abh. Berlin. Akad.

Trachelomonas lagenella Stein. 1878. Infusionsthier, III.

Lorica light-brown, elliptical or somewhat quadrate, surface smooth, Aperture generally produced into a short oblique tube. Length about 33 μ .

This is not more plentiful than *T. cylindrica* locally, and has not been found by the writer in numbers sufficient for proper study. There is room for doubt whether this is the organism described and figured by Ehrenberg. Neither the lorica as observed nor Stein's figure resembles Ehrenberg's figure xxiv, Taf. II, *Infusionsthieren*. Assuming, however, for the present, an identity, *T. lagenella* Stein becomes *T. uchlora* in accordance with known rules.

***Trachelomonas urceolata* Stokes.**

Trachelomonas urceolata Stokes. 1887. Proc. Amer. Philos. Soc.

"Lorica vasiform, smooth, about twice as long as broad, the lateral margins slightly flattened, produced anteriorly in a short, subcylindrical neck, the borders somewhat everted, truncate, not oblique; posterior extremity not inflated, produced in an acuminate, tail-like prolongation; endoplasm enclosing numerous, probably amylaceous, corpuscles."

Dr. Stokes gives the length of lorica in this remarkable species at the equivalent of about $4\frac{1}{2}\mu$, and the "habitat, pond-water." It has been observed by the writer in some abundance in living condition in a gathering from Riverton, New Jersey. It was accompanied by *T. volvocina*, *armata* and *piscatoris*. It differs remarkably from familiar species of the genus in the proportionately wide aperture, and in the thin, easily distorted, parchment-like lorica. The surface of the lorica in these specimens was not smooth, but profusely tuberculate, and the caudal process showed in some cases two or three appressed setæ. The material containing this form was made available through the kindness of Mr. Edward Potts.

***Trachelomonas eurystoma* Stein.**

Trachelomonas eurystoma Stein. 1878. Infusionsthier, III.

Lorica brown, broadly ovoid, obtusely pointed posteriorly, surface entirely smooth. Aperture surrounded by a short, wide rim with crenulated edge. Length 30μ .

Apparently rare in Delaware Valley. It has been observed, in numbers too small for proper study, in gatherings made in Tinicum. The crenulation of the wide, shallow rim around the aperture is not always evident.

***Trachelomonas torta* Kellicott.**

Trachelomonas torta Kellicott. 1885. Proc. Amer. Soc. Micros.

"Egg-shaped colorless, ornamented by oblique rugosities, giving the appearance of having been twisted; aperture situated in a short oblique groove; flagellum very long; animalcule green, with red eyespot."

Length of lorica, the equivalent of $50\ \mu$.

This is one of the largest of the genus, and one of the rarest in Delaware Valley. The writer has seen at most three specimens, and in one of these the lorica was colored a deep brown.

Trachelomonas armata (Ehr.) Stein. Pl. XLI, figs. 9, 10 and 11.

Chaetotrypha armata Ehrenberg. 1833. Abh. Berlin. Akad.

Chaetotrypha aspera Ehrenberg. 1833. Abh. Berlin. Akad.

Trachelomonas armata Stein. 1878. Infusionsthier, III.

Trachelomonas acanthostoma Stokes. 1887. Proc. Amer. Philos. Soc.

"*C. armata*. C. corpore ovato, utrinque rotundato, subgloboso, fusco, ubique setis brevibus hispido, corona apiculorum postica, nigra.

"*C. aspera*. C. corpore oblongo, fusco, utrinque rotundato, ubique setis brevibus hispido, apiculus posticis minoribus sine ordine sparsis."—Ehrenberg, *Abh. Berlin. Akad.*, 1833.

Lorica ellipsoidal, brown, the general surface densely and finely punctate. Two irregular rows of short, conical spines around aperture. Often a ring of six to twelve or more long, hollow, curving spines around posterior end. Aperture in a shallow, wide, rimmed depression, and infrequently produced into a short tube with stellate limb. Length of lorica $39\ \mu$.

This species is common in Delaware Valley and it exhibits much variety of form. But among the thousands of specimens examined, not one has shown a lorica with the smooth surface attributed to the species by authors. Dr. A. C. Stokes has accurately described his form *acanthostoma* as having a punctate surface. This would unquestionably be a specific distinction were it not true that all forms of *T. armata*, as found in this region, have precisely the same punctation.

The posterior ring of large, curving spines seems to be a very late excrescence in the individual development, and these spines may be seen in all stages of sprouting.

Trachelomonas crebea Kellicott. Pl. XLI, fig. 1.

Trachelomonas crebea Kellicott. 1887. Proc. Amer. Soc. Micros.

"Lorica spheroidal, varying from decided brown to colorless, elliptical in side view, length to breadth as 5 to 4; surface not spined, but with minute raised points over entire surface. Anterior projection hyaline, minutely notched and slightly everted at outer extremity, $\frac{1}{5}$ length of shell."

The length of lorica is given by Kellicott at the equivalent of $25\ \mu$. This species, as it occurs along the Delaware, where it is not uncommon, presents some variations. A prevalent form, figured herewith, is indefinitely and coarsely punctate, the punctæ being of various sizes

and shapes. The aperture is produced into a curving tube, coarsely toothed and not everted at the extremity. It reaches a length of 30 μ . A curious circumstance is that individuals of this description habitually swim in a reverse direction, that is to say, with aperture in the rear.

Forms with straight aperture-tubes are not wanting, but they are not common in the territory.

Trachelomonas hispida (Perty) Stein.

Chatoglena volvocina Ehrenberg. 1833. Abh. Berlin Akad.

Chonemonas hispida Perty. 1852. Lebensformen.

Trachelomonas hispida Stein. 1878. Infusionsthier, III.

Lorica brown, ovoid to long-elliptical, ends equally rounded. Surface mostly densely hispid throughout, occasionally nearly smooth. Aperture plane or produced into a short, cylindrical, hyaline tube.

A common and variable species, presenting all its well-known shapes in the Delaware Valley. A very small, tail-like, hyaline projection is sometimes present on the posterior end. The maximum size attributed to the species by Saville Kent is about the equivalent of 40 μ , but it is usually much smaller, and mostly about 30 μ . An occasional specimen has measured as high as 42 μ .

Trachelomonas caudata (Ehr.) Stein.

Chatoglena caudata Ehrenberg. 1840. Monatsberichte der Berliner Akad.

Trachelomonas caudata Stein. 1878. Infusionsthier, III.

Lorica brown, elongate-ovoid, acuminate posteriorly and produced into a conspicuous, hyaline, tail-like process. Surface densely hispid. Aperture in a long, hyaline, trumpet-form tube with everted and deeply dentate limb.

A rare species, but occurring in typical form in Tinicum. It is said to reach a length of 52 μ . The local specimens measured at most 40 μ . The spiny ornamentation is precisely like that of *T. hispida*, but there is never any trouble in distinguishing the two. This species is figured by Perty (*Zur Kenntniss Kleinster Lebensformen*, 1852, Tab. X, fig. 14) under the name of *Chonemonas acuminata*.

Trachelomonas obtusa sp. nov. Pl. XLI, fig. 3.

Lorica brown, with straight sides, rounded in front, abruptly conical posteriorly. Surface clothed with short, slender spines. Aperture not produced, bordered by a smooth area. Monad green with red pigment-spot. Flagellum long.

Lorica 33 μ long, 16 μ broad. Fresh-water ditches and ponds.

This species is not rare, but it has not yet been found in any large numbers in a single gathering. It occurs in tidal ditches in Tinicum,

and in ponds among aquatic plants at Riverton, New Jersey. It presents no notable peculiarities beyond the characteristics of the lorica. The spines are like those of *T. bulla* and *T. piscatoris*, being more sparse and slender than in *T. hispida*. Its very considerable size, and often-times its well-developed color, would preclude the obvious suspicion that it represents an immature state of some other species. Moreover, intermediate forms have not been observed.

Trachelomonas piscatoris (Fisher) Stokes.

Laguncula piscatoris Fisher. 1880. Proc. Amer. Soc. Micros.

Trachelomonas piscatoris Stokes. 1886. Jour. Trenton Nat. Hist. Soc.

"Lorica flask-shaped, cylindrical, less than twice as long as broad, the surface clothed by numerous short, conical spines; both extremities equally rounded, the anterior aperture produced into a smooth, cylindrical, neck-like prolongation, about one-seventh the entire length of the lorica, the frontal border denticulate and often bearing a row of short, conical spines similar to those on the general surface. . . ."

The length of lorica is given by Dr. Stokes, from whom the above is quoted, at the equivalent of 25-39 μ . It is a beautiful and very distinct species, not at all rare in Delaware Valley. It is present in most gatherings from Tinicum, and it occurs abundantly in lily-ponds at Riverton, New Jersey. In shaded situations, or where the water is poor in salts of iron, the lorica is sometimes light in color and thin-walled. This is probably the form referred to, but not adequately described nor at all figured, by Archer (1880, *Annals and Magazine of Natural History*), who suggested in a tentative way the name *T. acanthophora*.

Trachelomonas horrida sp. nov. Pl. XLI, fig. 6.

Lorica ovoid, brown, the general surface tuberculate, beset with very long, nearly straight, prismatic, abruptly pointed spines, longer on the ends than on the sides. Aperture plane, or produced into a short trumpet-shaped tube with wavy limb. Monad green, pigment-spot obvious. Flagellum long.

Fresh-water ditches. Length of lorica 40 μ .

This species is at once separated from all others by the character of the spines, as well as by their distribution. These spines are nearly as long as those of *T. armata*, but are not confined to certain areas, and are straight instead of curved, angular instead of round in cross-section, and pointed like a dagger. Those on the ends are 6 μ to 7 μ long, those on the sides one-half as long. It is also distinguished from *T. armata* by the tuberculate surface and the character of the aperture. Collected in living condition in Tinicum ditches, June and July, 1905.

While not plentiful, it presented itself in a number of gatherings containing also *T. volvocina*, *hispida* and *piscatoris*.

This same species has also been collected in Iowa by Prof. C. H. Edmundson, who has kindly sent specimens for identification and comparison with Eastern forms.

EXPLANATION OF PLATE XLI.

- Fig. 1.—*Trachelomonas crebea*, a prevalent form, not typical
- Fig. 2.—*Trachelomonas verrucosa*.
- Fig. 3.—*Trachelomonas obtusa*.
- Fig. 4.—*Trachelomonas Stokesiana*, front view.
- Fig. 5.—*Trachelomonas Stokesiana*, side view.
- Fig. 6.—*Trachelomonas horrida*.
- Fig. 7.—*Trachelomonas rugulosa*, front view.
- Fig. 8.—*Trachelomonas rugulosa*, side view.
- Fig. 9.—*Trachelomonas armata*, posterior spines undeveloped
- Fig. 10.—*Trachelomonas armata*, posterior spines partially developed.
- Fig. 11.—*Trachelomonas armata*, posterior spines developed.